DOCUMENT RESUME

ED 381 126 IR 016 961

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TITLE Advantages of a Theory-Based Curriculum in Instructional Technology.
PUB DATE 8 Feb 95
NOTE 18p.; Paper presented at the Annual Convention of the Association for Educational Communication and Technology (Anaheim, CA, February 8, 1995).
PUB TYPE Information Analyses (070) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS College Role; *Curriculum Design; *Educational Technology; Epistemology; Graduate Study; Higher Education; Teaching Methods; *Theories; *Theory Practice Relationship; *Universities
IDENTIFIERS *Instructional Theory

ABSTRACT

The purpose of this paper is to prove that including a significant theoretical component in instructional technology curricula has numerous advantages. The discussion is confined to curricula offered at universities, typically at the graduate level. Three topics are discussed: (1) the current state of instructional technology programs; (2) why theory is needed and what that theory should be; and (3) the role of the university in preparing instructional technologists. It is argued that curricula in university programs that train instructional technologists tend to emphasize practice at the expense of understanding. Because there are other agencies better suited to train practicality, universities should devote their resources to making sure students have a good grounding in the theories which immediately support what they do. Theories describe the complete range of human learning and includes perceptual and human factors theory, cognitive theories of learning, and theories of how knowledge guides the way people interact with their environment. It is contended that mastery of this theory should be attained by every student in instructional technology, and its application as the graduate develops professional skill and status will improve the success of the profession. (Contains 41 references.) (MAS)

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Advantages of a Theory-Based Curriculum in Instructional Technology

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Presented at the Annual Convention of the
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Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?

T.S. Eliot, Fourth Chorus from "The Rock".

Introduction

The purpose of this paper is to make the case that including a significant theoretical component in Instructional Technology curricula has numerous advantages. The discussion is mainly confined to curricula offered at universities, typically at the graduate level, where most academic training of instructional technologists takes place. Many types of organization are involved in preparing instructional technologists besides universities, including school districts, community colleges and industrial training departments. As I shall argue later, each is best suited to make a particular kind of contribution. This paper focuses on university curricula because universities are best suited to contributing in the area of theory. It is also the arena with which I am the most familiar.

The paper deals with three topics: The current state of instructional technology programs, why we need theory and what that theory should be, and the role of the university vis-à-vis other institutions in preparing instructional technologists. The discussion is supported by references to research and theory, to current practices and to personal experiences.

Current State of Instructional Technology Programs

It is, of course, extremely difficult to generalize about instructional technology programs. What is more, one's knowledge, assumptions and conclusions are derived from only those programs that are familiar, which might well include only those one studied in or within which one has worked. It is therefore necessary to talk more generally about the state of the field as it appears in the professional and academic literature and make suggestions about the role of theory on that basis. With these qualifications in mind, the current state of the instructional technology field may be characterized, I believe, as follows.

There is a heavy emphasis on "how-to-do-it" and less on "why-do-it". The need for instructional technologists to be trained in the practical skills of doing instructional design, message design, writing software and so on is a major force in shaping any instructional technology curriculum. Indeed, one of the few characteristics of instructional technology that makes it distinguishable from other disciplines within education is that it is concerned with the application of knowledge not just its generation. This idea arises again and again in definitions of technology (Galbraith, 1971), instructional

technology (AECT, 1977; Heinich, 1984) and instructional design (Glaser, 1976; Simon, 1981).

The emphasis on application has led, logically and understandably, to the pursuit of prescriptions for instruction. Scholars and practitioners see their greatest contributions to be discovering the best ways to teach and sharing these discoveries in the form of instructional principles and models. Reigeluth's (1983) discussion of prescriptive instructional theory (and its relations to descriptive theory and theories of learning) still stands as the most important and lucid account of the issue. He explains that the principles of prescriptive theory make statements about which instructional methods are most effective given instructional outcomes to attain and the conditions under which they must be achieved. The other chapters in his books illustrate this basic idea in a variety of instructional theories of varying completeness (Reigeluth, 1983) and provide examples of their application (Reigeluth, 1987).

There is, however, a danger in the unfettered pursuit of prescriptions. It creates the supposition, (which is extremely appealing to beginning students, by the way), that chosing instructional methods can be proceduralized. If research and experience generate enough principles about instructional methods, outcomes and conditions, then the strategy selection and development part of instructional design can be codified as a set of "if-then" rules -- methods can be looked up in a table in which a list of outcomes intersects a list of conditions to make a matrix, each of whose cells contains a prescription.

There are two problems with this approach. The first is that it makes instructional design entirely empirical. The iterative nature of instructional design requires that, once a method or entire model has been selected on the basis of conditions and outcomes, the instruction be tested. If it does not work, another method is tried and it tested in turn. The assumption is that eventually an optimal method will be found and all will be well. I will say more about the fallacy of this assumption in the next section. But for now, let me just remark that it assumes that the number of instructional principles is both finite and knowable. If instructional design fails, we assume it is because we have chosen the wrong principle, not that prescription might simply be impossible, or that we have mis-analyzed the outcomes and conditions, not that it is simply impossible to predict which method will work the best.

The second problem with the hunt for prescriptions is that, even if they were finite and knowable, using them in any procedural way would be impossible. Cronbach and Snow (1977) realized that this was the case with just one "conditions" factor, student aptitude. An instructional designer

might believe, after testing a unit of instruction, that a particular method did not work because the learner analysis was too coarse-grained. The designer goes back and discovers that the students for whom the unit is designed vary on both verbal and spatial ability and should be divided into four groups (high-verbal high-spatial, high-verbal low-spatial, low-verbal high-spatial, low-verbal low-spatial). The designer creates and tests a different strategy, prescribed from instructional theory to be the best for each group, each involving a different method. Again, testing gives less than acceptable results. The designer discovers next that the students also vary in motivation. Taking high and low-motivated students into account now requires a possible eight strategies for high-verbal high-spatial high-motivated, high-verbal high-spatial low-motivated, ... etc. Taken to its logical extreme, a separate method might be required for each student. A theory of instruction that contains a prescription for every combination of learning outcome and student chanarcteristic will collapse under its own weight, as aptitude-treatment-interaction theory (Cronbach and Snow, 1977) did when people tried to use it as a framework for instruction rather than as a framework for research.

Unfortunately, the idea that instructional design is a procedure and no more is reinforced by the way it is often taught. Most basic instructional design texts (for example, Dick & Carey, 1985; Gagne, Briggs and Wager, 1988) start off describing a graphic "model" of the process. Each box describes a task to perform; the arrows between the boxes indicate which task gets performed when. The idea quickly gets instilled that if you follow the arrows in the "model", completing each box as you encounter it, good instruction is sure to ensue. I recall the case of a student learning basic instructional design as an independent study course. After setting a goal and learning "the model", the student phoned about two weeks into the semester to say, "I have to change my project. I have nothing to put in box 23.4.1.2." If this is the way we are teaching ID (and I was obviously as guilty as anyone else of teaching it this way), then we are doing our students a great disservice.

There are two other characteristics of instructional technology programs that I will mention but briefly. The first is that, in some places, production is still taught as an end in itself. The argument for this part of the curriculum is that instructional technologists need to know all about media production even if they are going to be designers who never touch a camera, computer, or pot of glue again. In theory, this argument holds water. However, the dependence of instructional technology curricula on the availability of expensive production facilities puts entire programs at risk in times of budget-cutting. More on this later.

Finally, when theory is taught, it is often taught separate from courses where it needs to be applied. Courses in Educational Psychology are certainly

useful. However, if the exposure of instructional technology students to theory stops there, then the courses are largely wasted. Preparation to work in our field requires the opportunity to bring theory to design and application in a direct manner. This may require the construction of new theory courses taught by instructional technologists for instructional technology students. Again, I shall return to this later.

In sum, our current programs reflect our conception of the field. Theory is played down in favor of being practical, which is seen the clearest in the proceduralizing instructional design. This is dangerous because it implies that instructional theory is finite and knowable. We often teach production for its own sake; and theory is not integrated with practice. In the next section I will elaborate on some of these ideas and examine why we need to study theory at all.

Why Do We Need to Study Theory?

The short answer is, "Because instructional design procedures often don't work." In this section, I will deal with two issues. The first is why the procedures of instructional design often let us down. The second is how an understanding of theory can help compensate for the fallibility of instructional design procedures. The implication is that teaching theory, that is integrated with practice, in our instructional technology programs can make instructional method selection as rational as it is currently empirical, obviating the need for a finite and completely knowable prescriptive instructional theory, the assumption of which got us into trouble in the first place.

The procedures of instructional design do not work in those cases where the link between given instructional outcomes and conditions and useful methods is only weakly causal, correlational rather than causal, or non-existent. What is more, they do not work well when the instructional principles they reference describe sufficient rather than necessary conditions for learning to occur (see Clark, 1983). These cases pertain whenever student behavior, after exposure to an instructional method, is not entirely predictable. I have presented elsewhere (Winn, 1990, 1993) evidence for the unpredictability of human behavior and will summarize the main ideas shortly. The important point is that if outcomes cannot be relied upon to follow from prescribed methods, instructional prescriptions lack validity. For example, knowing that providing knowledge of results may or may not lead to better retention and comprehension, there can be no valid prescriptive principles about providing knowledge of results in instruction. And without valid prescriptive principles, all the task and learner analysis in the world, and an infinite number of test-revise iterations, will never produce effective instruction. At that point, instructional design procedures, instructional

prescriptions, and empiricism generally, break down; instructional designers have to think for themselves!

There are many reasons to question the predictability of human behavior. I will mention a few of the more important ones. The first is that, within the cognitive rather than the behavioral world view, the factors that mediate between the perceived stimulus (method) and student performance (outcome) vary greatly in their nature and effect from individual to individual. The role of individual differences in learning has been the object of much research within cognitive psychology (Snow, 1992, 1994; Sternberg, 1994; Tobias, 1989). As we have already seen, the complexity that arises from attempting to write prescriptions for individual differences gives rise to intractable problems for instructional designers (Cronbach and Snow, 1977). This means that any significant variation between the students for whom the instructional designer is designing instruction and the subjects in the studies that gave rise to relevant instructional presciptions renders those prescriptions invalid. For different kinds of students, it is not possible to predict what outcomes will ensue from using the same methods.

The second reason to doubt the predictability of human behavior arises from the study of metacognition. If students have metacognitive ability, they are able to monitor the success of the strategies they are using to learn and to change strategies if they think a different approach would be more effective. If this happens, the students is in effect saying to the designer, "Look, I tried learning it your way, and it didn't work for me. So I tried another strategy." It is obvious that if students can switch methods in this way, there is no way the designer can predict which method will be used nor, therefore, what outcome will occur.

Third, a number of researchers (for example, Brown, Collins and Duguid, 1989; Lave and Wenger, 1991) are telling us that what students actually learn is determined by the situation in which learning takes place (the environment) rather than what the student brings to learning (knowledge of the world and cognitive abilities.) This "radical constructivist" view (Sternberg, 1994) carries with it the assumption that, since the instructional designer can never know exactly what the learning situation will be, it is impossible to predict exactly what the outcome will be. Merrill (1992) has argued that deliberate decontextualization to teach abstractions is useful and therefore important for instructional designers to do. However, the growing evidence for the situatedness of learning suggests at the very least that context, rather than prior knowledge or instructional method, sometimes determines outcomes and that, in fact, this could be the case the majority of the time.

Finally, people do not think logically. They make decisions from incomplete information, play hunches and make guesses (Collins, 1978; Schon, 1983; Suchman, 1987). On the other hand, the instructional designer assumes that students think as logically, and therefore as predictably, as the computer, teacher, video or text that teaches them. If the student departs from the logic of the lesson, then the outcome is uncertain at the very least. This lack of planfulness in human cognition has led Streibel (1991) to conclude that cognitive science can never be the basis for instructional design. And I have made the point (Winn, 1987, 1993) that, because of this, the activities of the instructional designer need to take place at the time the student is working with the instructional material, not beforehand. This means that methods can be selected or developed "on the fly" and in immediate response to what students think and do.

If instructional design is less effective than people would like because its basic premise -- that human behavior is predictable -- is frequently untenable, how can an understanding of theory help? A careful reading of prescriptive instructional theory (Fleming & Levie, 1993; Gagne, Briggs & Wager, 1988; Reigeluth, 1983, 1987) will reveal that instructional principles are not intended to be used as hard-and-fast rules for method selection but rather as signposts to the pathways through that rich and complex literature. In other words, instructional design is not strictly or even predominantly empirical. Rather the designer is expected to bring reason and experience to instructional decision-making in a dialectical process between the empirical and the rational that is analogous to the interplay between learning context and a student's knowledge that I mentioned above.

When the procedural approach to instructional design fails, the emphasis shifts from the empirical to the reasoned approach to method selection. This "reasoning from first principles" (Winn, 1989) has much in common with Schon's (1983, 1987) concept of "reflection in action" and something in common with more general conceptions of expertise (Chi, Glaser & Farr, 1988). It requires the designer to reason at one step removed from the immediate problem at a more abstract level. For example, when an instructional prescription fails, the designer approaches the problem through learning theory. If knowledge of results (an instructional prescription) fails to produce learning, the designer does not try another instructional prescription but rather thinks through what processes are engaged (learning theory) when the student is processing the feedback. This knowledge may lead to the selection of an entirely new approach, perhaps without any feedback at all, rather than to an attempt to improve the feedback. It may lead to the invention, on the spot, of a new instructional principle. (In this case, the designer needs to conduct a small, spontaneous experiment to verify the effectivesness of the new strategy. Schon [1983] describes exactly this process

taking place when professionals solve problems.) The designer then returns to the problem directly with the new solution.

Two ideas arise from "reasoning from first principles". The first is that any discipline (except perhaps physics) is based on another more general, abstract and underlying discipline from which it draws. In the case of instructional design, that discipline is psychology, as we have just seen. (It is interesting to trace a discipline to its logical roots in this way. Psychology draws on neuroscience. Neuroscience draws on biochemistry. Biochemistry draws on chemistry. Chemistry draws on physics. In fact, every discipline from psychiatry to engineering to sociology to haute cuisine can trace its roots to physics. Try it. Maybe that's why physics departments are so high in the pecking order in the academic community!)

The second idea is that any successful practitioner or researcher needs to be thoroughly versed in at least the immediately underlying discipline to his or her own. A good instructional designer knows psychology. A good architect knows engineering. A good zoologist knows biology. What is more, the successful practitioner must be able to slip effortlessly from one discipline to the other, and know when to do so. Reflection on problems, enabled by knowledge of underlying theory whose greater abstraction gives you more room for thought, is an expedient way to find new and creative solutions.

What theory should students of instructional technology study? Clark (1989) has suggested that instructional technologists need to be masters of just about every discipline in the social sciences: Psychology, sociology, economics, politics, anthropology and so on. I do not believe such eclecticism is necessary or even wise. If we look at what happens when someone learns something, the chain of events points to a number of bodies of theory that belong to the immediately foundational science instructional designers must subscribe to. Learning proceeds as follows:

Data. The world is bathed in all kinds of energy. Humans can only detect a relatively small portion of this -- what we can see, hear, taste, smell and feel by means of our senses. The data that we can detect form the basis for everything we learn and know about the world. The limited range of data to which we have access explains why, for example, we can never know what it is like to be a bat (Nagel, 1974).

Information. Our senses not only detect data, but impose structure on them. Data receive form to become information. Most of this is achieved pre-attentively (Arbib & Hanson, 1987; Marr, 1982), meaning that we cannot wilfully control it (Pylyshyn, 1984). Yet the preattentive structure imposed on information predisposes what we make of it when we process it attentively (Owen, 1985; Duong, 1994).

Knowledge. As we attentively process the information we receive about the world, we develop our knowledge of how the world works. Cognitive processes by means of which new information is assimilated to existing knowledge, which accomodates to it in turn, are described in just about every theory of learning from schema theory (Neisser, 1976) to constructivism (Duffy & Jonassen, 1992).

Wisdom. Knowledge should be a means to end not an end in itself. And it is in the judicious application of knowledge that wisdom lies. Among Sternberg's definitions of wisdom (1990, p. 4) is "a virtue providing a compelling guide to action..." which leads to closer harmony between us and the physical universe. The acquisition of wisdom takes a long time -- we usually associate being wise with being old! Indeed, Csikszentmihalyi & Rathunde (1990) and Labouvie-Vief (1990) propose that wisdom develops during a stage of development that follows formal operations, throughout adulthood.

Learning theory, therefore, describes how data are transformed into information, information into knowledge and knowledge into wisdom. The first transformation is performed by physiological (perceptual) processes. The second is performed by cognitive processes and the third by environmental and cultural processes. This suggests that the instructional technologist needs a good grounding in physiological theory that relates to perception, in cognitive theories of learning and in anthropological theories of the influence of culture and environment on action.

The transformation of data into information can be indirect so that data that we cannot detect are converted into a perceptible form. Transducers are any instruments that convert one form a energy into another or shift its frequency to within the range of our senses, such as thermometers, geiger counters, microscopes, radio telescopes, radar, and so on. When I go looking for a shipwreck to dive on, a depth-sounder bounces sounds I cannot hear off the sea bottom that I cannot see and converts the echos into a colored picture on a CRT that is within the range of the visible spectrum.

Instructional designers need to understand how best to transduce and present information that is normally beyond the range of the human senses. The discipline that deals squarely with instrumentation, transduction and information display is human factors engineering. As we use more and more different technological means to interact with real, simulated and virtual enviroments, it is extremely important for instructional designers to be able select appropriate metaphors and design effective displays for transdused information. This requires knowledge of human factors theory.

To summarize this section, I have argued that we need theory to provide support to instructional designers when the empirical, prescriptive approach fails to identify effective instructional methods. I presented a selection from a large amount of evidence that such failure will frequently occur because instructional design only works well when human behavior can be reliably predicted from the application of instructional methods. The theory from which practitioners can profitably draw is that which forms the most immediate foundation for the discipline in which the original problem arose. For instructional designers, this means a knowledge of perceptual and cognitive theory, of how people eventually acquire wisdom as cognitive processes interact with the contexts in which people find themselves, and human factors.

The Role of the University

A recent essay in Scientific American, written by a Vice-President of Sony, a former Physicist but now running Sony's American entertainment ventures, made a very telling point. The essay was basically a criticism of American MBA programs and made the argument that basic scientists, like Physicists, are far better prepared to serve business and industry than MBAs. The reason is that MBAs are trained to apply prescriptions while basic scientists are trained to find new solutions to problems. The result, the author notes, is that when problems arise, MBAs see them as setbacks while basic scientists view them as opportunities to invent new approaches and develop new ideas. (Schon [1983] makes the similar point that effective professionals view difficulties as opportunities rather than obstacles.)

A recent comment made by Fred Brooks, Director of Computer Science at the University of North Carolina, provides an interesting contrast. While describing how students select and undertake doctoral research in his laboratory, he remarked, "Any fool can think of something new. It takes a really smart person to make something better." And replying to a student who asked when he would know he had finished his dissertation, he replied, "When your client is satisfied."

Superficially, these two examples suggest contrasting roles for the university in the preparation of practitioners. However, deep down, I believe that the difference is only a matter of whether theory precedes or follows application. For the MBA and for the instructional designer, theory is in place and ready to direct action. Theory precedes application. If prescriptions fail, then theory has let the practitioner down and a problem arises. For the basic scientist and for Brooks' student, theory is neither immutable nor sacrosanct. Application is neither directed nor hampered by theory. However, applications that fail may be improved by recourse to theory. Modifications to theory may be made as a result.

The contrast is even more striking when we look at the role of theory in research. For the MBA and the instructional designer, the purpose of research is to confirm theory. For the basic scientist, the purpose of theory is to explain the data that come from empirical research. (For Brooks' student, there was probably no need to explain anything to the client.) The difference is subtle but important. In graduate school, one of my friends was a psychopharmacologist. When I learned in my first experimental design course that it was possible to construct a hypothesis from theory, to design an experiment to test it, and compare the data with a mathematical model of what the theory predicted, I was eager to know how my friend applied this procedure to his own work on the neurochemistry of aggression. I was surprized, and disappointed, when he told me that his research group never constructed and tested hypotheses. Rather, they simply tried things out until they found something that worked and then tried to explain why.

In all of these cases, theory is present. Its role is different. More important, who develops it is different. For the MBA, theory development is someone else's responsibility. If theory fails, someone else has to fix it. For the basic scientist, like the Sony VP and my psychopharmacologist friend, changing theory is the responsibility of the practitioner. It is also the responsibility of the instructional designer who reasons from first principles. If an instructional prescription fails, the invention of one that works adds to or modifies instructional theory.

So what then is the role of the university in preparing instructional designers, and especially in giving them a good grounding in immediately underlying theory? We need to understand that universities cannot prepare instructional designers on their own. Instructional technology courses can provide no more than what Tennyson (1994) has identified as declarative knowledge about the discipline with perhaps some procedural knowledge through simulations and exercises. Internships may provide more procedural knowledge and a little contextual knowledge. However, the acquisition of true expertise as an instructional designer requires extensive apprenticeship (Lave & Wenger, 1991) or practicum (Schon, 1987), professional experience (Schon, 1983) leading to the automatization of behavior and the development of highly contextualized knowledge and intuition (Dreyfus & Dreyfus, 1986).

If we look at all the "players" in the preparation of instructional technologists, we find that other agencies are often better equipped than universities to provide components of that training. Many school districts are capable of doing a better job training teachers to use computers than universities. Often, they are better equipped than university labs. to offer workshops. And they are certainly more aware of district technology policies and of the immediate problems of integrating technology into curriculum.

Student instructional designers are therefore better off with what school districts offer for that part of their curriculum.

The same is true in the business and industrial sectors. For example, our program at the University of Washington accepts and places many students at Microsoft. My colleagues at Microsoft advise me not to waste my time teaching the students programming or even authoring using the particular tools the Corporation uses. I am assured that training in these kinds of skills can be learned easily and quickly through corporate training programs and on the job. However, I am told that the reason they hire our students is that they can think on their feet and can explain why they recommend and do things.

If other agencies are better than universities at preparing instructional designers in certain applications of technology and such skills as programming and authoring, the university has two important and unique contributions to make. The first is, of course, making the students aware of relevant theory. School districts and corporations have neither the time, the interest nor the expertise to teach instructional technologists psychology. The universities do. The second is the integration of theory with practice. Of course university students of instructional technology need to learn production skills, but only as means to the end of realizing their designs and trying them out, not as ends in themselves. With these skills in place, it is possible to bring theory directly into the laboratory. I teach two courses that do just this (though less successfully than I would like). Students have as their assignment to design and develop a piece of instructional software. Each 140 minute session is divided roughly into two parts. During the first part, we discuss research articles that have been assigned. I show program fragments that illustrate what a program would look like if the findings of the particular study were implemented prescriptively. We discuss the results. During the second part of the session, students work on their own projects, accepting or rejecting the prescriptive implications from the readings. Perhaps the most important student "product" is a paper in which they justify the design decsions they have made. Good grades go to students who say, "I did it this way because Doe [1989] said it should be done this way." Better grades go to those who say, "In spite of what Doe [1989] said, I did it this way because ...". The best grades go to those who say, "In spite of what Doe [1989] said, I did it this way. Doe is wrong because ..., and here is evidence of the greater effectiveness of my approach."

The other important contribution of universities is training instructional technologists in research. There is little need to dwell on this topic beyond stressing that many of our students pursue careers in universities and that universities are usually better equipped than school districts or corporations to teach personnel how to gather and analyze data.

If one accepts that the preparation of instructional designers cannot be accomplished by universities alone in the realtively short duration of a graduate program, then we must conclude that the job must be shared among several agencies. The role of the university lies primarily in bringing the research and theory of the basic disciplines to practitioners-in-training and to making sure that this theory is properly integrated into practice. It is wise and practical to leave preparation in specific tools, techniques and applications to the work place. Increasingly, the latter seems both acceptable and feasible.

Conclusion

I have argued that curricula in university programs that train instructional technologists tend to emphasize practice at the expense of understanding. Because agencies other than universities are better suited to train instructional technologists in such practical pursuits as media production, it follows that universities should devote their resources to making sure student instructional technologists have a good grounding in those theories that immediately support what they do. This is because instructional design cannot be strictly prescriptive since humans do not behave as predicted. When prescriptive theory fails, the instructional designer must be able to reason from "first principles" that reside in theory. Thinking on one's feet to solve problems is, after all, an attribute of any successful professional. The theory describes the complete range of human learning and includes perceptual and human factors theory, cognitive theories of learning and theories of how knowledge guides the way people interact with their environment. Mastery of this theory should be attained by every student of instructional technology. Application of it as the graduate develops professional skill and status will improve the success of our profession.

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